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Effects of anthropogenic disturbance on the vegetation of granitic and gneissic rock outcrops ('inselbergs') in West Africa

by

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Abstract: Inselbergs are isolated rock outcrops frequently consisting of granite or gneiss, and are widespread on the old crystalline continental shields. Due to harsh environmental conditions (i.e. lack of soil and water, high temperatures) their vegetation is markedly different from that of their surroundings. Typical is a specific set of habitat types such as cryptogamic crusts, monocotyledonous mats, rock pools, ephemeral flush vegetation and these are characterized by a distinct species inventory. Throughout the tropical and temperate zones, negative human impacts on inselbergs have increased dramatically over the past decades. Of particular importance have been fire, quarrying and tourism, all of which have led to the complete destruction of numerous inselbergs in many parts of the world. In order to assess the consequences of human activities, a specific habitat (*Afrotrilepis pilosa*-mats) was compared on disturbed and relatively undisturbed inselbergs situated in the savanna zone of Ivory Coast over a period of 10 years. The data show considerable differences in both species and life-form composition of the flora. Disturbed inselbergs were characterized by higher species numbers and diversity, as well as by a larger percentage of annuals, whereas inselbergs-specific species became locally extinct. Increased species richness on disturbed inselbergs was due to weedy species which were able to become established following anthropogenic fires. Observations from other tropical regions indicate that most inselbergs-specific vegetation types are also highly sensitive to human disturbance and are particularly susceptible to weedy species.

Key words: Conservation, disturbance, inselbergs, isolation, neophytes, weeds

Introduction

Isolated outcrops consisting of crystalline rock are globally distributed. In particular dome-shaped granitic and gneissic monoliths form striking landscape features which are clearly separated against their surroundings and were thus aptly named "inselbergs" (from German Insel = island and Berg = mountain) by the German geologist Wilhelm Bornhardt (1900). Under geological and geomorphological aspects inselbergs are fairly well known (cf. Bremer & Jennings 1978, Bremer & Sander 2000). It was only in the last decade that inselbergs became objects of increased biolo-

gical interest which resulted in the publication of several comprehensive treatments (see Hopper & Withers 1997, Porembski & Barthlott 2000).

Inselbergs are particularly frequent on the old crystalline continental shields. Due to their resistance to erosional processes they possess a considerable age frequently surpassing millions of years. Edaphically (i.e. lack of soil) and microclimatically (i.e. intense irradiation, temperatures regularly exceeding 60 °C) the environmental conditions on inselbergs are extreme (Szarzynski 2000). Even when situated in rainforest these rock outcrops thus form "microenvironmental deserts". Due to the harsh growth conditions inselbergs harbour many specialized plant species (e.g. desiccation-tolerant vascular plants). Besides drastic floristic differences between geographic and climatic regions this ecosystem comprises certain physiognomically defined habitat types which can be found on inselbergs in all tropical and temperate regions. Most characteristic are cryptogamic crusts on exposed rocks (covered by specialized lichens and cyanobacteria), shallow soil-filled depressions, monocotyledonous mats, rock pools and ephemeral flush vegetation. For more details about these habitats it is referred to Porembski et al. (2000).

Because of their low agricultural potential and also because of their importance for cultural and religious purposes in many parts of the world inselbergs were hitherto relatively well protected against anthropogenic disturbances. However, such as other rock outcrop communities too (e.g. cliffs cf. Larson et al. 2000) which support a unique vegetation, inselbergs have increasingly attracted a variety of human interests. The conservation and management of inselbergs located in temperate regions has already been in the focus of nature conservationsts (Withers & Hopper 2000) in contrast to their tropical counterparts. The aim of the present contribution is to examine the consequences of certain anthropogenic impacts on the vegetation of tropical inselbergs by comparing disturbed with undisturbed rock outcrops over a period of ten years. Within the framework of this study the following questions were addressed: 1) Which are the floristic differences (both quantitative and qualitative) between disturbed and undisturbed inselbergs? and 2) Are inselbergs sensitive towards the invasion of weeds?

Methods

All studies were conducted in the savanna region of Ivory Coast with regular monitoring work in the rainy seasons of 1991, 1994, 1997 and 2000. Permanent plots were established on 3 inselbergs showing clear signs of disturbing human influences (most of all fire) located near larger villages and on 3 inselbergs not immediately located near settlements showing no signs of human disturbance (s. Tab. 1). On each inselbergs 5 permanent plots were placed within mats formed by the long-lived and slow growing Cyperaceae *Afrotrilepis pilosa* (Boeck.) J. Raynal. This desiccation-tolerant chamaephyte covers open rocky slopes (Fig. 1) on inselbergs throughout West Africa (Richards 1957, Hambler 1964, Porembski et al. 1996). The mats of *A. pilosa* were

Tab. 1. Species richness of inselbergs and influence of fire.

Inselberg	Location	Fire	Average species diversity (H')
IB 1	8°49'N/5°11'W	no	0.54
IB 3	9°32'N/6°29'W	no	0.43
IB 18	8°42'N/3°35'W	no	0.51
IB 2	9°27'N/5°38'W	yes	1.66
IB 24	7°45'N/5°10'W	yes	1.22
P 47	8°42'N/3°35'W	yes	1.36

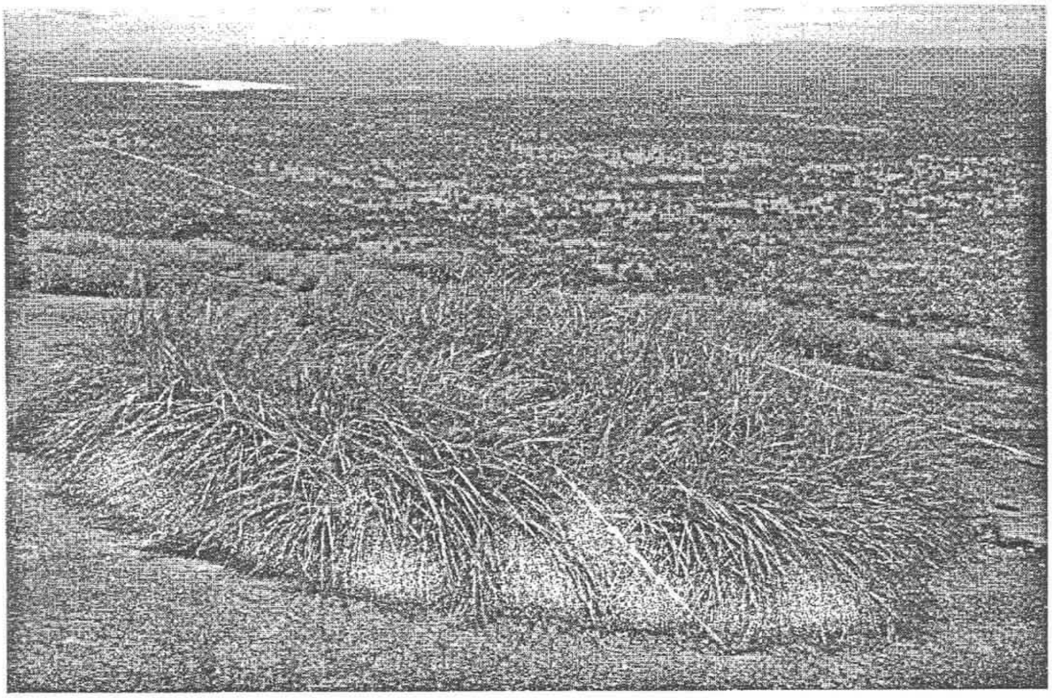

Fig. 1. Intact *Afrotrilepis pilosa*-mat on an inselberg in the north of Ivory Coast.

selected because our experience during inselbergs research in Ivory Coast over more than a decade has shown this inselbergs specific habitat type to be particularly sensitive to human disturbance. The mats chosen as permanent plots were circular in outline and covered an area of ca. 5 m^2. For each permanent plot the percentage cover of all vascular plants was recorded. As a measure of diversity, the Shannon index was calculated for each relevé.

Results

Human impact

The effects of human influence were clearly visible on the three inselbergs located in the surroundings of villages. Most prominent were traces of fire and grazing. During the whole study period annual fires damaged large parts of the inselbergs vegetation including the permanent plots. The fires were lit deliberately during the dry season. As a consequence of annual burning old specimens of *Afrotrilepis pilosa* attained a clump-like appearance and are relatively fires-resistant due to the possession of a protective sheath of adventitious roots (Fig. 2). Other types of human influence observed on the inselbergs studied were small-scale quarrying and drying of vegetables and clothing. The inselbergs classified as undisturbed were only occasionally visited by humans out of curiosity. However, harmful effects could not be detected and no signs of fire could be observed.

Species richness

The mean number (9.2) of species was highest on those inselbergs that showed clear signs of destructive human impacts. On average the annually burnt *A. pilosa*-mats contained more than

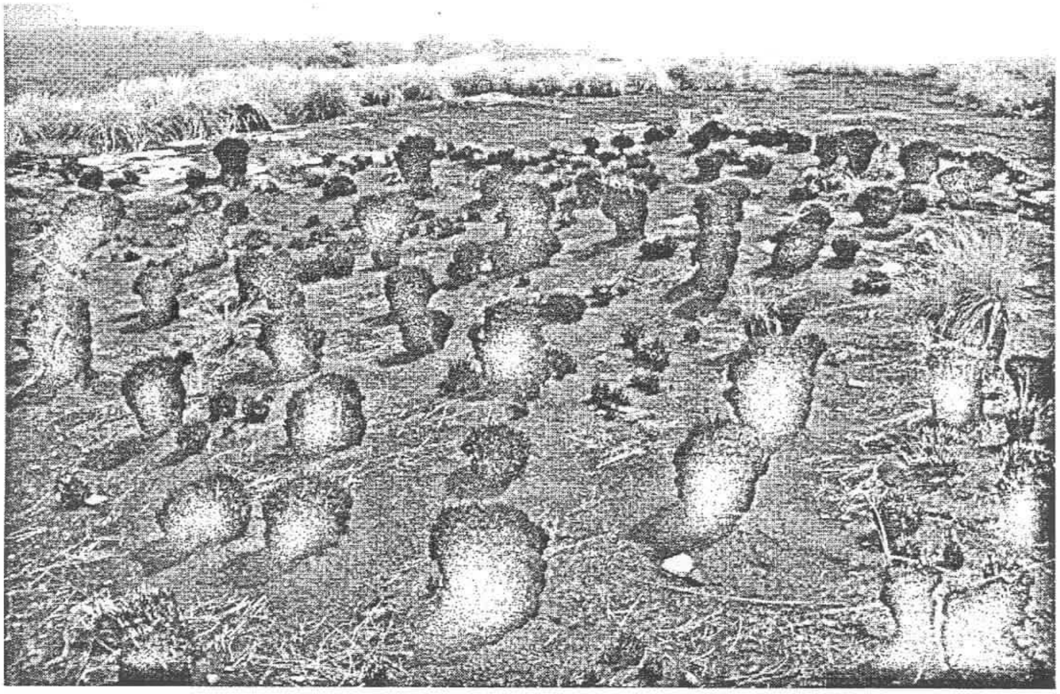

Fig. 2. Burnt *Afrotrilepis pilosa*-mats on inselberg located near a village. Frequent fires caused the clump-like appearance of the plants.

twice the number of species as unburnt mats (mean 4.72). Over the whole study period the number of species remained fairly constant within the plots on undisturbed inselbergs. Certain plots did not change in species richness and sometimes in percentage cover too over the whole 10-year study period. In contrast to this species richness changed rapidly after the burning of hitherto untouched *A. pilosa*-mats on disturbed inselbergs. Plant diversity (expressed as Shannon index H') of disturbed inselbergs (mean H' 1.42) was likewise significantly higher than on undisturbed inselbergs (mean H' 0.49). Rapid changes in species richness occurred on two disturbed inselbergs after the burning of formerly intact *A. pilosa*-mats. In these plots the number of species increased whereas the percentage cover of *A. pilosa* declined considerably.

Species composition and life-forms

Concerning the floristic inventory large differences could be observed between plots on undisturbed and disturbed inselbergs (Tab. 2). *Afrotrilepis pilosa* was the dominant species in all plots on undisturbed inselbergs. This species was accompanied by a set of inselbergs typical taxa such as *Asplenium stuhlmannii* Hieron. and *Polystachya microbambusa* Kraenzl. which were completely lacking in *A. pilosa*-mats on disturbed inselbergs. Plots on disturbed inselbergs showed a large percentage of annuals. This group contained both inselberg specific elements and weedy species with e.g. *Chamaecrista mimosoides* (L.) Greene and *Mollugo nudicaulis* Lam.. Among the weedy species widespread elements (e.g. *Fimbristylis dichotoma* Vahl) were frequent, however, only one neophyte [i.e. *Axonopus compressus* (Sw.) P. Beauv. from South America] was recorded. The plots on undisturbed inselbergs remained remarkably constant concerning their species inventories. In several cases there was no change in species composition over the whole study period. Annuals clearly outnumbered perennial species in the plots on disturbed inselbergs. On undisturbed inselbergs perennials were more speciose than short-lived species. However, certain annuals which mainly grow on rock outcrops [e.g. *Cyanotis lanata* Benth., *Lindernia exilis* (Skan)

Tab. 2. Species found on undisturbed (IB 1, IB 3, IB 18) and disturbed inselbergs (IB 2, IB 24, P 47).

	IB 1 1991, No.1	IB 1 1994, No.1	IB 1 1997, No.1	IB 1 2000, No.1
Afrotrilepis pilosa	80	80	80	80
Asplenium stuhlmannii	10	10	10	10
Cyanotis lanata	1	1	1	1
Lindernia exilis	?	?	?	?
Polystachya microbambusa	3	3	3	3
Sporobolus festivus	10	10	20	10
Virectaria multiflora	?	?	?	?

	IB 3 1991, No.1	IB3 1994, No.1	IB3 1997, No.1	IB3 2000, No.1
Afrotrilepis pilosa	70	80	70	70
Asplenium stuhlmannii	?	?	?	?
Cyanotis lanata	1	1	1	1
Lindernia exilis	1	1	1	1
Polystachya microbambusa	?	?	?	?
Sporobolus festivus	10	10	10	10
Virectaria multiflora	10	10	10	10

	IB 18 1991, No.1	IB 18 1994, No.1	IB 18 1997, No.1	IB 18 2000, No.1
Afrotrilepis pilosa	90	80	80	80
Asplenium stuhlmannii	3	3	10	10
Cyanotis lanata	1	1	1	1
Lindernia exilis	?	?	?	?
Polystachya microbambusa	?	?	?	?
Sporobolus festivus	1	1	1	1
Virectaria multiflora				

	IB 1 1991, No.2	IB 1 1994, No.2	IB 1 1997, No.2	IB 1 2000, No.2
Afrotrilepis pilosa	80	80	80	80
Asplenium stuhlmannii	10	10	10	10
Cyanotis lanata	1	1	1	1
Hibiscus scotellii	10	10	10	10
Hymenodictyon floribundum	?	?	?	?
Sporobolus festivus	1	1	1	1
Virectaria multiflora	?	?	?	?

	IB 3 1991, No.2	IB3 1994, No.2	IB3 1997, No.2	IB3 2000, No.2
Afrotrilepis pilosa	90	90	90	90
Asplenium stuhlmannii	?	?	?	?
Cyanotis lanata	1	1	1	1
Hibiscus scotellii	?	?	?	?
Hymenodictyon floribundum	?	?	?	?
Sporobolus festivus	10	10	10	10
Virectaria multiflora	10	10	10	10

	IB 18 1991, No.2	IB 18 1994, No.2	IB 18 1997, No.2	IB 18 2000, No.2
Afrotrilepis pilosa	80	80	80	80
Asplenium stuhlmannii	?	?	?	?
Cyanotis lanata	1	1	1	1
Hibiscus scotellii	?	?	?	?
Hymenodictyon floribundum	20	20	20	20
Sporobolus festivus	3	3	10	10
Virectaria multiflora	?	?	?	?

	IB 1 1991, No.3	IB 1 1994, No.3	IB 1 1997, No.3	IB 1 2000, No.3
Afrotrilepis pilosa	60	60	70	70
Asplenium stuhlmannii	?	?	?	?
Bulbostylis coleotricha	1	1	1	1
Cyanotis lanata	1	1	1	1
Lindernia exilis	1	1	1	
Sporobolus festivus	10	10	20	10

	IB 3 1991, No.3	IB3 1994, No.3	IB3 1997, No.3	IB3 2000, No.3
Afrotrilepis pilosa	80	80	70	70
Asplenium stuhlmannii	?	?	?	?
Bulbostylis coleotricha	?	?	?	?
Cyanotis lanata	1	1	1	1
Lindernia exilis	1	1	1	1
Sporobolus festivus	3	3	1	1

	IB 18 1991, No.3	IB 18 1994, No.3	IB 18 1997, No.3	IB 18 2000, No.3
Afrotrilepis pilosa	90	90	90	90
Asplenium stuhlmannii	3	3	3	3
Bulbostylis coleotricha	?	?	?	?
Cyanotis lanata	1	1	1	1
Lindernia exilis	1	1	1	1
Sporobolus festivus	10	10	10	10

	IB 1 1991, No.4	IB 1 1994, No.4	IB 1 1997, No.4	IB 1 2000, No.4
Afrotrilepis pilosa	70	70	70	70
Asplenium stuhlmannii	10	10	10	10
Cyanotis lanata	1	1	1	1
Lindernia exilis	?	?	?	?
Sporobolus festivus	10	10	20	10

	IB 3 1991, No.4	IB3 1994, No.4	IB3 1997, No.4	IB3 2000, No.4
Afrotrilepis pilosa	90	90	90	90
Asplenium stuhlmannii	?	?	?	?
Cyanotis lanata	1	1	1	1
Lindernia exilis	1	1	1	1
Sporobolus festivus	10	10	10	10

	IB 18 1991, No.4	IB 18 1994, No.4	IB 18 1997, No.4	IB 18 2000, No.4
Afrotrilepis pilosa	80	80	80	80
Asplenium stuhlmannii	10	10	3	3
Cyanotis lanata	1	1	1	1
Lindernia exilis	1	1	1	1
Sporobolus festivus	1	1	1	1

	IB 1 1991, No.5	IB 1 1994, No.5	IB 1 1997, No.5	IB 1 2000, No.5
Afrotrilepis pilosa	80	80	80	80
Asplenium stuhlmannii	10	10	10	10
Cyanotis lanata	1	1	1	1
Hymenodictyon floribundum	?	?	?	?
Lindernia exilis	?	?	?	?
Solenostemon laterifolius	1	3	3	3
Sporobolus festivus	10	10	10	10
Tripogon minimus	1	1	1	1

	IB 3 1991, No.5	IB3 1994, No.5	IB3 1997, No.5	IB3 2000, No.5
Afrotrilepis pilosa	70	70	80	80
Asplenium stuhlmannii	?	?	?	?
Cyanotis lanata	1	1	1	1
Hymenodictyon floribundum	?	?	?	?
Lindernia exilis	1	1	1	1
Solenostemon laterifolius	?	?	?	?
Sporobolus festivus	20	20	10	10
Tripogon minimus	?	?	?	?

	IB 18 1991, No.5	IB 18 1994, No.5	IB 18 1997, No.5	IB 18 2000, No.5
Afrotrilepis pilosa	80	70	80	80
Asplenium stuhlmannii	10	10	10	10
Cyanotis lanata	1	1	1	1
Hymenodictyon floribundum	10	10	20	20
Lindernia exilis	1	1	1	1
Solenostemon laterifolius	?	?	?	?
Sporobolus festivus	1	1	1	1
Tripogon minimus	?	?	?	?

	IB2, 1991, No.1	IB2, 1994, No.1	IB2, 1997, No.1	IB2, 2000, No.1
Aeollanthus pubescens	3	3	10	10
Afrotrilepis pilosa	60	60	50	40
Borreria scabra	1	1	1	1
Bulbostylis coleotricha	?	?	?	?
Chamaecrista mimosoides	?	1	1	1
Cyanotis lanata	1	1	1	1
Emilia spec.	?	?	?	?
Fimbristylis dichotoma	1	1	1	1
Indigofera astragalina	?	?	?	?
Indigofera spec.	?	?	10	?
Lindernia exilis	1	1	1	1
Microchloa indica	?	1	?	1

	IB24, 1991, No.1	IB24, 1994, No.1	IB24, 1997 No.1	IB24, 2000, No.1
Aeollanthus pubescens	?	?	?	?
Afrotrilepis pilosa	60	20	20	20
Borreria scabra	?	10	10	3
Bulbostylis coleotricha	1	3	3	10
Chamaecrista mimosoides	?	?	?	?
Cyanotis lanata	1	10	10	10
Emilia spec.	?	3	3	10
Fimbristylis dichotoma	?	10	10	3
Indigofera astragalina	?	?	?	?
Indigofera spec.	?	?	?	?
Lindernia exilis	1	1	1	3
Microchloa indica	1	1	1	1

	P47, 1991, No.1	P47, 1994, No.1	P47, 1997, No.1	P47, 2000, No.1
Aeollanthus pubescens	10	3	3	10
Afrotrilepis pilosa	20	20	30	20
Borreria scabra	1	1	3	1
Bulbostylis coleotricha	?	?	?	?
Chamaecrista mimosoides	1	1	1	1
Cyanotis lanata	3	10	10	20
Emilia spec.	?	?	?	?
Fimbristylis dichotoma	10	10	10	10
Indigofera astragalina	10	10	10	?
Indigofera spec.	?	?	?	?
Lindernia exilis	1	1	1	1
Microchloa indica	1	?	?	1

Tab. 2. Species found on undisturbed (continued)

Mollugo nudicaulis	1	1	1	1	?	1	1	1	1	1	?	?
Pennisetum polystachion	10	10	20	20	?	?	?	?	?	?	?	?
Polystachya microbambusa	?	?	?	?	10	?	?	?	?	?	?	?

	IB2, 1991, No.2	IB2, 1994, No.2	IB2, 1997, No.2	IB2, 2000, No.2	IB24, 1991, No.2	IB24, 1994, No.2	IB24, 1997 No.2	IB24, 2000, No.2	P47, 1991, No.2	P47, 1994, No.2	P47, 1997, No.2	P47, 2000, No.2
Aeollanthus pubescens	?	?	?	?	?	?	?	?	?	1	1	1
Afrotrilepis pilosa	30	30	30	20	70	30	30	30	20	20	30	10
Borreria scabra	1	1	10	1	10	3	1	1	1	1	3	10
Bulbostylis coleotricha	1	1	1	1	?	1	1	10	1	3	3	3
Chamaecrista mimosoides	1	1	1	1	?	1	1	1	1	1	1	3
Cyanotis lanata	1	?	1	1	1	3	3	10	10	10	10	20
Emilia spec.	?	?	?	?	?	1	?		?	?	?	?
Fimbristylis dichotoma	10	10	3	10	?	10	10	10	10	10	10	20
Indigofera astragalina	?	?	?	?	?	?	?	?	10	10	10	10
Indigofera spec.	3	3	3	3	?	?	?	?	?	?	?	?
Lindernia exilis	1	1	1	1	1	1	1	1	1	1	1	1
Microchloa indica	3	1	1	1	1	1		1	1	?	?	1
Mollugo nudicaulis	?	?	1	1	?	1	1	1	1	1	?	1
Pennisetum polystachion	?	?	?	?	?	?	?	?	?	?	?	
Sporobolus festivus	?	?	?	?	10	3	20	20	1	1	1	3

	IB2, 1991, No.3	IB2, 1994, No.3	IB2, 1997, No.3	IB2, 2000, No.3	IB24, 1991, No.3	IB24, 1994, No.3	IB24, 1997 No.3	IB24, 2000, No.3	P47, 1991, No.3	P47, 1994, No.3	P47, 1997, No.3	P47, 2000, No.3
Aeollanthus pubescens	10	1	?	3	?	?	?	?	10	3	3	3
Afrotrilepis pilosa	20	30	30	20	50	10	10	10	70	60	10	10
Borreria scabra	1	1	1	1	3	?	1	1	?	?	1	1
Bulbostylis coleotricha	10	1	1	1	?	10	1	1	?	?	1	1
Chamaecrista mimosoides	?	?	1	1	?	3		1	?	?	1	1
Cyanotis lanata	1	1	1	1	1	10	3	10	?	?	10	20
Emilia spec.	?	?	?	?	?	?	1	?	?	?	?	?
Fimbristylis dichotoma	?	3		3	1	10	10	3	?	?	3	?
Indigofera astragalina	?	?	?	?	?	3	1	3	?	?	?	?
Lindernia exilis	1	1	1	1	1	1	1	1	1	1	1	1
Microchloa indica	3	1	1	1	1	1	1	1	?	?	3	1
Mollugo nudicaulis	?	1	?	?	?	?	1	?	?	?	1	1
Portulaca oleracea	1	1	1	1	?	?	?	?	?	?	?	?
Pennisetum polystachion	30	20	20	20	?	?	?	?	?	?	?	?
Sporobolus festivus	1	3	3	1	1	3	10	10	1	1	1	1

	IB2, 1991, No.4	IB2, 1994, No.4	IB2, 1997, No.4	IB2, 2000, No.4	IB24, 1991, No.4	IB24, 1994, No.4	IB24, 1997 No.4	IB24, 2000, No.4	P47, 1991, No.4	P47, 1994, No.4	P47, 1997, No.4	P47, 2000, No.4
Aeollanthus pubescens	1	1	10	1	?	?	?	?	10	10	3	1
Afrotrilepis pilosa	30	30	20	20	70	30	30	30	80	30	20	20
Borreria scabra	?	?	?	?	?	3	1	1	?	1	1	1
Bulbostylis coleotricha	?	?	?	?	?	?	?	?	?	?	?	?
Chamaecrista mimosoides	1	1	1	1	?	1	1		?	?	?	1
Cyanotis lanata	10	10	10	10	1	1	3	10	1	10	20	20
Cyanotis longifolia	1	1	1	1	?	?	?	?	?	?	?	?
Fimbristylis dichotoma	3	?	1	1	?	?	3	1	?	1	1	1
Indigofera astragalina	?	10	10	10	?	?	?	?	?	10	3	3
Lindernia exilis	1	1	1	1	1	1	1	1	1	3	1	1
Microchloa indica	1	1	1		?	?	1	1	?	?	?	?
Mollugo nudicaulis	1	1	1	1	?	?	1	?	?	1	1	1
Pennisetum polystachion	20	20	20	20	?	?	?	?	?	?	?	?
Polycarpaea eriantha	?	?	?	?	?	?	?	?	?	1	1	1
Sporobolus festivus	3	1	3	3	1	1	1	1	1	10	10	10

	IB2, 1991, No.5	IB2, 1994, No.5	IB2, 1997, No.5	IB2, 2000, No.5	IB24, 1991, No.5	IB24, 1994, No.5	IB24, 1997 No.5	IB24, 2000, No.5	P47, 1991, No.5	P47, 1994, No.5	P47, 1997, No.5	P47, 2000, No.5
Aeollanthus pubescens	3	3	10	3	?	?	?	?	1	3	3	3
Afrotrilepis pilosa	30	30	30	30	80	30	30	30	80	20	10	10

Tab. 2. Species found on undisturbed (continued)

Borreria scabra		1 ?		1	1	?		3	1	1	?		1	1	1
Bulbostylis coleotricha	?	?	?	?		?		1	1	1	?	?	?	?	
Chamaecrista mimosoides		1	1 ?		1	?		1		1	?	?		1	1
Cyanotis lanata		10	10	3	10		1	1	3	10		1	10	10	10
Cyanotis longifolia		1	1	1	1	?	?	?	?		?	?	?	?	
Fimbristylis dichotoma	?		3	3	10	?	?		1	1	?	?		1	1
Indigofera astragalina	?	?	?	?		?		10 ?		1	?	?		1	1
Lindernia exilis	?	?	?	?			1	1	1	1	?		1	1	1
Microchloa indica		1	1	1	1	?	?		1	1	?		1	1	1
Mollugo nudicaulis		1	1			?	?		1 ?		?	?		1	1
Pennisetum polystachion		10	20	20	20	?	?	?	?		?	?	?	?	
Polycarpaea eriantha	?	?	?	?		?	?	?	?		?		1	1	1
Portulaca oleracea	?	?		1	1	?	?	?	?		?	?	?	?	
Schwenckia americana		1	1	1	1	?	?	?	?		?	?	?	?	
Sporobolus festivus		3	3	10	3	?		1	3	3		1	10	10	10

Philcox] were typical constituents of the *A. pilosa*-mats on undisturbed inselbergs. In *A. pilosa*-mats both species composition as well as life-form spectrum changed rapidly after the burning of mats on disturbed inselbergs. Relatively short after the first fire on the inselbergs IB 24 and P 47 the percentage cover of *A. pilosa* was drastically reduced and considerable numbers of annuals were recorded thereafter.

Discussion

Throughout the world inselbergs form ecologically isolated ecosystems which bear a unique vegetation. Today, in many regions rock outcrops frequently are the last refuges of natural vegetation types. In forming striking landscape features inselbergs have early attracted the consideration of man for religious and mythological reasons and formed objects of worship (Seine 2000). Together with their low agricultural value this later fact might explain why inselbergs have conserved much of their specific attributes.

In many tropical regions inselbergs situated in anthropogenically converted landscapes experience increased human pressure. In particular inselbergs situated in seasonally dry regions are seriously affected by man-lit fires. These fires are often lit out of curiosity since especially during the night it is a spectacular view to see a whole mountain being literally burnt. Many plants on inselbergs are not well adapted to withstand deliberately lit fires and are thus critically reduced in numbers. Fire is particularly frequent in mat communities such as those formed by *A. pilosa* since the dry leaves of this poikilohydric species are easily lit. The comparative analysis presented here shows that regular burning of mats on Ivorian inselbergs strongly influenced by human impacts caused a decline of *A. pilosa* percent coverage and led to an increased species richness due to invading weedy annuals. Concomitant with the decrease of *A. pilosa* cover a number of characteristic accompanying species vanished rapidly from regularly burnt mats. The later group of plant species is not fire resistant and their absence from *A. pilosa*-mats thus indicates a certain degree of human impact on the vegetation of inselbergs. Observations of intact *A. pilosa*-mats made in the course of this long-term study underline that this community consists of relatively few but highly specialized elements. Under natural circumstances this mat community is characterized by low vegetation dynamics and remains fairly constant over large periods with regard to species composition and dominance structure.

Own observations in other tropical regions (e.g. Brazil) emphasize that disturbing anthropogenic effects which are particularly strong in the vicinity of human settlements will cause the ruderalisation of the vegetation of inselbergs. In the frame of this process the number of plant species possessing weedy attributes (i.e. possessing effective means of dispersal, short life-cycle) increases. Among the later group neophytes may play an important role (Porembski 2000, Porembski et al. 1998) but were almost lacking on the inselbergs investigated.

On the inselbergs studied, disturbance not only led to increased species richness but caused a dramatic change in the life-form spectrum as well. Remarkably quick therophytes attained dominance in *A. pilosa*-mats after they became burnt for the first time. Fire sensitive species like the chamaephyte *Asplenium stuhlmannii* and the host specific orchid *Polystachya microbambusa* (restricted to *A. pilosa*-mats, see Porembski 2005) disappeared directly after a fire. All regularly burnt plots in *A. pilosa*-mats showed a seriously reduced soil cover by plants. On several occasions it could be observed that these stands are much more susceptible towards soil erosion which results in poorer regeneration conditions. Intact *A. pilosa*-mats are firmly attached to the underlying rock by an intense system of wiry roots. Partly destroyed mats may lose adhesive strength to the rock which sometimes results in the dislodgement of whole mats following heavy rains. Since *A. pilosa*-mats form a relatively slow growing plant community destructive impacts will not be compensated by rapid regeneration. In being by far the most important mat-building species on West African inselbergs increasing human pressure due to higher frequencies of fire could

rapidly cause a strong reduction in the extent of these mats or even their complete disappearance locally on inselbergs located in the neighbourhood of human settlements. The destruction of *A. pilosa*-mats could lead to a population decline of species restricted to this habitat (e.g. orchids like *Polystachya microbambusa*). Similarly plants such as the numerous terrestrial species of the carnivorous genus *Utricularia* which develop during the rainy season along the wet periphery of the mats would lose their growth sites. Based on own experience it can be stated that the situation on the disturbed inselbergs studied is no exception but rather the rule in many parts of West Africa. *Afrotrilepis pilosa*-mats constitute a key-stone habitat on West African inselbergs that is particularly sensitive towards human lit fires. The destruction of *A. pilosa*-mats not only results in the above mentioned loss of typical vegetation attributes of inselbergs but may also promote in the long-term the establishment of weeds including neophytes. The relatively small number of neophytes on the disturbed inselbergs might be indicative of a rather recent human influence on them. In other tropical and temperate regions inselbergs have been observed that became massively infested by invasive neophytes [e.g. *Melinis repens* (Willd.) Zizka on Brazilian inselbergs, Porembski et al. 1998]. On the other hand inselbergs losing their character as terrestrial habitat islands (due to human induced changes in their surroundings) are not only prone to become invaded by neophytes but they also may become potential sources of future weeds as could be demonstrated by Wyatt (1997).

Granite outcrops are prominent landscape features in nearly all continental areas (Twidale 2000). Apart from fire the use of this ecosystem for quarrying is among the most serious threats to it in all tropical and temperate regions. In certain localities the establishment of permanent tourist facilities and the subsequent damage of the rock outcrop vegetation have already reached alarming dimensions. Moreover, outdoor activities such as rock climbing and mountainbiking (and other forms of off-road driving) may cause severe damage to the highly sensitive inselbergs plant communities. Similar problems were reported from other rock outcrop communities too (Kelly & Larson 1997). For a number of taxa (e.g. desiccation-tolerant vascular plants, see Porembski & Barthlott 2000) inselbergs form centers of diversity. They thus represent genetic refuges for a considerable number of species which are restricted to them as growth sites. Up to now management strategies for the long-term maintenance of this ecosystem have only rarely been developed (e.g. in Australia, Hopper 2000) but are urgently needed for the future conservation of the vegetation of inselbergs over large geographic scales.

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